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A comparative analysis of ABE Bachelor of Science programmes in European and US Universities

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Abstract. *European Universities are involved in series of great changes regarding teaching and education organization during the last few years. The origin of these changes is the creation of the so-called European Higher Education Area (EHEA), which main target is to harmonize the different University studies throughout Europe. As a consequence, most of the programs of studies in all degrees are suffering changes in order to converge to common structures. Taking advantage of the actual process, some European universities are moving from traditional Agricultural Engineering programs to a more wide discipline named recently as Biosystems Engineering, which is a science-based engineering discipline that integrates engineering science and design with applied biological, environmental and agricultural sciences, broadening in this way the area of application of Engineering sciences not strictly to agricultural sciences, but to the biological sciences in general, including the agricultural sciences. This paper presents a comparative study of different Bachelor of Science degrees offered by American and European Universities in the field of Agricultural/Biosystems Engineering. To carry out the analysis 40 programs accredited by ABET in American Universities and 50 European programs. Among other questions, the total number of credits, the number of semesters, the kind of modules and the distribution of subjects in groups (Basic Sciences, Engineering Fundamentals, Agricultural/Biological Sciences, Humanities & Economic Sciences, Applied Agricultural/Biological Engineering and electives) are discussed in the paper. The information provided can be an useful starting point in future definitions of new or renewed degrees with the aim of advancing in internationalization of the programs and helping student's mobility.*

Keywords. *University studies, ABE, Agricultural & Biological Engineering, EHEA.*

Introduction

European universities are involved in series of profound changes regarding teaching and education organization during the last few years. The main cause of this new scenario is the creation of the so-called European Higher Education Area (EHEA), which main objective is to harmonize university studies though Europe.

In 1998, the Ministers of Education of France, Germany, Italy and the United Kingdom signed a declaration in the Sorbonne (Paris) urging the creation of a "European Higher Education Area", as a first step to establish a common structure for university studies in Europe. Later, in 1999, more than 30 European countries committed by the Bologna Declaration to reform by 2010 the structures of their higher education systems towards a common model based on two cycles ('undergraduate studies' and 'master') and a common system to measure (the ECTS credit equivalent to 25-30 hours of work carried out by the student).

The adaptation of university degrees to the EHEA guidelines in Spain occurred through the Royal Decree 1393/2007, aimed at developing the structure for official university degrees (Bachelor of Science, Master and PhD) and the procedure to be verified and approved by the Government. Unlike the previous system, in which the catalog of university degrees and the minimum contents to be taught in each of them were established by the Government, the Royal Decree 1393/2007 stipulates that universities are the institutions responsible for proposing and designing degrees and curricula, to be later evaluated and approved by a national quality assurance agency (ANECA = Agency for Quality Assessment and Accreditation).

A bachelor's degree constitutes the first cycle university studies in Europe. These studies are worth 180- 240 ECTS credits (3-4 years), corresponding to core subjects, compulsory and optional courses, seminars, training internships, final-year project and other educational activities. A total of 60 ECTS credits will measure the workload of a full-time student during one academic year, which is equivalent to 1500-1800 hours of work. In those studies in which training internships are contemplated, they should cover a maximum of 60 ECTS credits and will be preferably offered in the second half of the curriculum. The final-year project, meanwhile, is a common requirement in engineering studies and has a workload ranging between 6 and 30 ECTS.

Official master's degrees are aimed to provide advanced and specialized training for students to prepare them for academic or professional careers, or provide an initiation to research work. Master's degrees comprise between 60 and 120 ECTS credits, spread over one or two academic years.

During the last few years, Agricultural Engineering studies in Europe have been facing problems such as a decrease in recruitment, less prestige of the professionals and lack of definition in the kind of courses that should be included in the programs (Alcalde et al. 2005; Briassoulis et al, 2008). For this reason and taking advantage of the current situation, some universities are currently changing their traditional agricultural engineering programs into the wider area of Biosystems Engineering. That science-based engineering discipline integrates engineering science and design with applied biological, environmental and agricultural sciences, broadening in this way the area of application of Engineering sciences not strictly to agricultural sciences, but to the biological sciences in general, including the agricultural sciences (Paganakis et al, 2008).

The present paper contributes a comparison between Bachelor of Science degrees in the area of Agricultural and Biosystems Engineering that are currently offered by various US and European universities. The designation of the degrees, the total number of credits, the number of semesters and the distribution of the credits constituting the curriculum into Basic Sciences, Humanities & Economic Sciences, Engineering Fundamentals; Agricultural & Biological Sciences Courses, Applied Agricultural & Biological Engineering Courses or Electives, among some other questions, are discussed in the paper. The information provided can be useful in the current context of defining new or renewed degrees, which main objective should be to advance towards the internationalization of the curriculum and the mobility of the students (Wolfe et al. 2011).

Materials and methods

To carry out the present analysis information has been compiled from the curricula corresponding to 40 Bachelor of Science degrees in Agricultural and/or Biosystems Engineering currently taught in US universities and accredited by ABET and 50 Bachelor of Science programs taught in European universities that were included in the ERABEE database 'Agricultural and Biosystems Engineering University Studies in Europe' (Briassoulis et al. 2010).

Table 1 provides the full list of Bachelor of Science degrees considered in the study.

Table 1. List of Bachelor of Science degrees considered in the study

US Universities

B.Sc. in Biosystems Engineering **[Auburn University]**
B.Sc. in BioResource and Agriculture Engineering **[California Polytechnic State University]**
B.Sc. in Biosystems Engineering **[Clemson University]**
B.Sc. in Biological Engineering **[Cornell University]**
B.Sc. in Biological and Agricultural Systems Engineering **[Florida Agricultural and Mechanical University]**
B.Sc. in Biological Systems Engineering **[Iowa State University]**
B.Sc. in Biological & Agricultural Engineering **[Kansas State University]**
B.Sc. in Biological Systems Engineering **[Kansas State University]**
B.Sc. in Biological Engineering **[Louisiana State University]**
B.Sc. in Biosystems Engineering **[Michigan State University]**
B.Sc. in Biological Engineering **[North Carolina State University]**
B.Sc. in Agricultural and Biosystems Engineering **[North Dakota State University]**
B.Sc. in Food, Agricultural and Biological Engineering **[The Ohio State University]**
B.Sc. in Biosystems Engineering **[Oklahoma State University]**
B.Sc. in BioEngineering **[Oregon State University]**
B.Sc. in Agricultural Engineering **[Purdue University]**
B.Sc. in Biological and Food Process Engineering **[Purdue University]**
B.Sc. in Agricultural and Biosystems Engineering (ABE) **[South Dakota State University]**
B.Sc. in Biological & Agricultural Engineering **[Texas A & M University]**
B.Sc. in Biosystems Engineering **[University of Arizona]**
B.Sc. in Biological and Agricultural Engineering (BAEG) **[University of Arkansas]**
B.Sc. in Biological Systems Engineering **[University of California, Davis]**
B.Sc. in Agricultural and Biological Engineering **[University of Florida]**
B.Sc. in Agricultural Engineering (BSAE) **[University of Georgia]**
B.Sc. in Biological Engineering (BSBE) **[University of Georgia]**
B.Sc. in Biological and Agricultural Engineering (BAE) - **[Biological Systems Engineering] [University of Idaho]**
B.Sc. in Biological and Agricultural Engineering (BAE) - **[Agricultural Engineering] [University of Idaho]**
B.Sc. in Agricultural and Biological Engineering - Agricultural Eng. Concentration **[University of Illinois at Urbana-Champaign]**
B.Sc. in Agricultural and Biological Engineering - Biological Eng. Concentration **[University of Illinois at Urbana-Champaign]**
B.Sc. in Biosystems & Agricultural Engineering **[University of Kentucky]**
B.Sc. in Biological Engineering **[University of Maine]**
B.Sc. in Biological Resources Engineering **[University of Maryland]**
B.Sc. in Bioproducts and Biosystems Engineering **[University of Minnesota-Twin Cities]**
B.Sc. in Biological Engineering (BE) **[University of Missouri-Columbia]**
B.Sc. in Agricultural Engineering **[University of Nebraska-Lincoln]**
B.Sc. in Biological Systems Engineering **[University of Nebraska-Lincoln]**
B.Sc. in Biosystems Engineering **[University of Tennessee at Knoxville]**
B.Sc. in Biological Systems Engineering **[University of Wisconsin-Madison]**
B.Sc. in Biological Engineering **[Utah State University]**
B.Sc. in Biological Systems Engineering (BSE) **[Virginia Polytechnic Institute and State University]**

European Universities

B.Sc. in Environment and Bio-Resources Management **[Universität für Bodenkultur Wien]**
B.Sc. in Biosystems Engineering **[Catholic University of Leuven]**
B.Sc. in Agricultural Engineering **[Agricultural University of Plovdiv]**
B.Sc. in Agricultural Techniques and Technology **[Angel Kanchev University of Rousse]**
B.Sc. in Agricultural Engineering **[Angel Kanchev University of Rousse]**
B.Sc. in Agricultural Machinery **[Czech University of Life Sciences-CULS]**
B.Sc. in Road Transportation and City Traffic **[Czech University of Life Sciences-CULS]**
B.Sc. in Waste Disposal Technology and Techniques **[Czech University of Life Sciences-CULS]**
B.Sc. in Technological Equipment of Constructions **[Czech University of Life Sciences-CULS]**
B.Sc. in Trade and Business Dealing with Machinery **[Czech University of Life Sciences-CULS]**
B.Sc. in Information and Control Technology in Agri-food Complex **[Czech University of Life Sciences-CULS]**
B.Sc. in Agricultural Machinery **[Mendel University]**
B.Sc. in Biosystem Engineering **[Estonian University of Life Sciences]**
B.Sc. in Agricultural Engineering **[University of Helsinki]**
B.Sc. Plant Biotechnology **[Leibniz University of Hannover]**
B.Sc. in Agricultural Sciences **[University of Hohenheim]**
B.Sc. in Agricultural Engineering **[Agricultural University of Athens]**
B.Sc. in Agricultural Engineering **[Aristotle University of Thessaloniki]**
B.Sc. in Agricultural Engineering **[University of Thessaly]**
B.Sc. in Agricultural Engineering **[Szent Istvan University]**
B.Sc. Biosystems Engineering **[University College Dublin]**
B.Sc. in Sciences of Agricultural and Forestry Land and Environment **[University of Bologna]**
B.Sc. in Agricultural Technologies for Environment and Land **[University of Milan]**
B.Sc. in Land Restructuring and Landscape Protection (Landscape, Parks and Gardens) **[University of Padua]**
B.Sc. in Land Restructuring and Landscape Protection (Land Protection and Restructuring) **[University of Padua]**
B.Sc. in Agricultural Engineering **[University of Palermo]**
B.Sc. in Landscape Technical Management **[University of Perugia]**
B.Sc. in Sciences and Technologies for Forest and Nature Protection (Ecological Eng.) **[University of Tuscia – Viterbo]**
B.Sc. in Sci. and Tech. for Forest and Nature Protect. (Management of Protected Areas) **[University of Tuscia – Viterbo]**
B.Sc. in Agricultural Engineering **[Latvia University of Agriculture]**
B.Sc. in Mechanical Engineering (Agricultural Machinery) **[Lithuanian University of Agriculture]**
B.Sc. in Energetics (Agricultural Power Engineering) **[Lithuanian University of Agriculture]**
B.Sc. Biosystems Engineering (in Dutch: B.Sc. Agrotechnologie) **[Wageningen University]**
B.Sc. in Renewable Energy **[Norwegian University of Life Sciences]**
B.Sc. in Agricultural Engineering **[University College of Hedmark]**
B.Sc. in Informatics in Agricultural Engineering **[University of Life Sciences in Lublin]**
B.Sc. in Food Engineering **[University of Life Sciences in Lublin]**
B.Sc. in Animal Science Engineering **[University of Évora]**
B.Sc. in Diplomirani biosistemsi inženir (VS) **[University of Maribor]**
B.Sc. in Agricultural Engineering and Science **[Technic University of Madrid]**
B.Sc. in Food Engineering **[Technic University of Madrid]**
B.Sc. in Agro-environmental Engineering **[Technic University of Madrid]**
B.Sc. in Agricultural Engineering **[Technic University of Madri**d]
B.Sc. in Agrarian and Rural Engineering **[University of León]**
B.Sc. in in Agro-alimentary Industries **[University of León]**
B.Sc. in Agro-environmental Engineering **[University of León]**
B.Sc. in Forestry and Natural Resources **[University of León]**
B.Sc. in Technology **[Swedish University of Agricultural Sciences]**
B.Sc. in Agricultural Engineering (Agricultural Machinery) **[Ege University]**
B.Eng. (Hons) Agricultural Engineering **[Harper Adams University College]**

The total number of credits, the number of semesters and the complete list of courses has been obtained for each particular degree. The different subjects that made up the syllabus of each particular BS degree have been classified according to the following categories: (i) General Education; (ii) Basic Sciences; (iii) Humanities & Economic Sciences, (iv) Engineering Fundamentals; (v) Agricultural & Biological Sciences Courses, Applied Agricultural & Biological Engineering Courses and (vii) Electives.

In order to establish and compare the length of the studies provided at European and US universities the following equivalence has been used 1 US semester credits = 1,7 European Credits; whereas 1 US credit is equivalent to 15-17 hours of class, while 1 ECTS usually assumed a workload of 10 hours of class. In those Bachelor of Science degrees from US universities whose curricula are structured by quarters (i.e. California Polytechnic State University, Ohio State University or University of California-Davis, among some others) the equivalence 1 quarter credit = 0,667 semester credit has been established.

Results

As shown in Table 1, while the Bachelor of Science degrees offered in US universities frequently include in the designation the terms 'Biosystems Engineering' or 'Biological Engineering', in the case of the BS degrees offered in European universities greater variability and specificity can be found in the designation of the studies. The terms ‘Agricultural engineering’, ‘Agro-environmental engineering’ ‘Forestry engineering’ or ‘Food engineering’ are commonly used in the European context.

Table 2 provides information concerning the average length of the Bachelor of Science degrees in US and European universities, expressed in both semesters and ECTS credits (1 ECTS = 10 hours of class).

Table 2. Average length of the Bachelor of Science degrees in US & Europe

	US Universities	European Universities
Semesters (Average)	8	6,72
Total ECTS credits	220 [206-231]	210 [180-324]

As shown in Table 2, Agricultural and Biosystems Engineering undergraduate degrees are structured into 8 or 9 semesters in most US universities, with a workload ranging between 123 and 136 semester credits (equivalent to 206-224 ECTS). The length of the Bachelor of Science degrees in Europe is more variable, ranging from 6 to 10 semesters with a global workload varying from 180 to 324 ECTS.

The distribution of the credits that constitute the curriculum in General Education, Basic Sciences, Humanities & Economic Sciences, Engineering Fundamentals, Agricultural & Biological Sciences Courses, Applied Agricultural & Biological Engineering Courses and Electives are shown in Table 3.

Table 3. Distribution of the credits that constitute the curriculum of ABE Bachelor of Science degrees by blocks

	US Universities	European Universities
General Education	17% [7-23%]	
Basic Sciences	25% [16-32%]	20% [9-57%]
Humanities & Economic Sciences	2% [0-11%]	9% [0-40%]
Engineering Fundamentals	15% [2-30%]	24% [0-74%]
Agricultural & Biological Sciences Courses	7% [0-16%]	22% [0-90%]
Applied Agricultural/Biological Engineering Courses	19% [0-33%]	19% [0-50%]
Electives	13% [0-27%]	7% [0-33,3%]

Curriculum for Agricultural & Biosystems Engineering Bachelor of Science degrees offered by US universities usually contains 'General Education' requirements which include topics such as 'American History', 'Cultural Analysis', 'Literature and Arts', 'Fitness & Wellness', 'Public Communication' 'Writing', and so on. The ‘General Education’ block usually represents between 7 and 23% of the total credits of the program. This type of generalist education is not usually included in the curricula of European universities.

‘Basic Sciences’ include different courses related to 'Mathematics', 'Physics', 'Chemistry', 'Statistics' and 'General Biology' areas. This kind of education is present in both the curricula of US and Europe universities, with greater weight in the first ones (25% vs. 20%). The weight of Basic Sciences subjects in the Bachelor of Science degrees curriculum in Europe is quite variable, ranging from 9 to 57% of the total credits.

The weight of the courses corresponding to 'Engineering Fundamentals' and 'Agricultural & Biological Sciences' is generally higher in European universities, although greater variability can be found. Students should complete a final-year project to complete their B.S. studies in over 80% of the European universities selected for this research. In the rest of the European universities the Final Project is just optional. The number of credits assigned to the final project varies between 4 and 30 ECTS. A training internship in a company is also common in European Agricultural & Biosystems Engineering B.S. degrees. The number of credits assigned in the curriculum to that ‘Practice stage’ can range from 1 to 60 ECTS.

Conclusions

A comparative study of the different Bachelor of Science degrees offered by American and European Universities in the field of Agricultural/Biosystems Engineering is presented in this paper. The information provided is useful in the current context of defining new B.Sc. degrees, one of whose main objectives should be advancing towards the internationalization of the programs and the mobility of the students. The main concussions of this work are summarized below:

- The European universities are currently involved in series of great changes regarding teaching and degrees organization. In this context, some European universities are beginning to move from traditional Agricultural Engineering programs to the wider discipline of Biosystems Engineering.
- Degrees in the field of Agricultural Engineering offered by US universities usually include in their designation the terms 'Biosystems' or 'Biological'. In the case of European universities greater variability and specificity can be found in the designation of the studies. The terms ‘Agricultural’, ‘Environmental’ ‘Forestry’ or ‘Food’ are frequently used to designate the degree.
- US universities usually offer courses in 'General Education' as a part of the B.Sc. curriculum. This block represents between 7 and 23% of total credits of the program. This type of generalist education is not usually included in the curricula of European universities.
- ‘Basic Sciences’ courses ('Mathematics', 'Physics', 'Chemistry', 'Statistics' or 'General Biology') are present in the curricula of both American and European universities, with a higher weight in the US (25% vs. 20%). It should also be noted that the weight of the ‘Basic Sciences’ subjects in the curricula of the B.Sc. degrees of the European universities is quite variable, ranging from 9 to 57% of the total credits.
- B.Sc. programs offered by European Universities usually demand the complete a final final-year project in order to complete their studies. The number of credits assigned to the final-year project varies from 4 to 30 ECTS credits. A training internship in a company is also common in Europe, representing a workload between 1 and 60 ECTS.

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